FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO

1948

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FEDERAL EXPERIMENT STATION IN PUERTO RICO
MAYAGUEZ, PUERTO RICO

Administered by the Office of Experiment Stations, Agricultural Research Administration, United States Department of Agriculture

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[1] In cooperation with the Government of Puerto Rico.

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INTRODUCTION

In the following pages there is a summary record of the accomplishments of the Federal Experiment Station in Puerto Rico during the fiscal year 1948. The method of presentation is changed with this report. Prior to 1941, it was the general policy to publish all the work in the annual reports or as bulletins and circulars of the station, rather than in individual scientific papers. During the war period the use of illustrations was discontinued, but the research findings were still reported in considerable detail in the annual reports. The present report contains only summary statements of the more important activities and accomplishments. It is hoped that this will make it more readable and will facilitate early publication. References to more detailed scientific information are given when papers on a particular subject have been published, and a list of publications issued during the year is given.

The agricultural research program of the Federal station has deviated somewhat during the past year. A cooperative project was initiated between the Soil Conservation Service, the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Agricultural

Experiment Station of the University of Puerto Rico, and the Federal Experiment Station. The project carried on under the heading "Soil Erosion Control and Stable Crop Production in Puerto Rico," is supported by Research and Marketing Act funds and Insular funds, and was organized under the supervision of R. M. Smith. The initial project has been directed toward forage management and improvement and soil physics studies. The main contribution of the Federal station to this project has been cytogenic studies on grasses and legume breeding and testing.

In general, the established policy of the station—the conducting of investigations of importance to continental agriculture—was continued during 1948. In this respect, special attention has been given to insecticidal plants, mainly *Derris*, and to drug crops, particularly *Cinchona*. Many of the projects directed toward improvement of continental agriculture, however, were also of immediate and local benefit to the agricultural economy of Puerto Rico. Breeding work with sweetpotatoes, tomatoes, papayas, and other crops has also been started this year.

Three years of extensive vegetable trials in different sections of the island have been completed, and the results will be reported in a station bulletin.

Investigations partially or wholly supported by Insular funds included work on vanilla, bamboo, spices, and weed control. The lath-shade method for growing vanilla is showing increasing promise, and, as a result, an experimental planting on a semicommercial scale has been started in cooperation with the Mayaguez Tropical Products Co. The bamboo program sponsored by the Insular Government is also proving highly successful. New bamboo industries have been established, utilizing a considerable number of laborers and locally grown bamboo previously introduced by the station.

Widespread interest in tropical kudzu has continued, and numerous requests were received for seed and information on this valuable legume.

Considerable quantities of plant material have been exchanged with the Office of Foreign Agricultural Relations. Likewise, results of research carried on at this station have contributed materially to agricultural progress in Latin America. Cooperative work with other agencies is given throughout the report.

A weekly station seminar was initiated this year, in which all technical personnel and many visitors participated.

PERSONNEL

The following changes occurred in the Federal staff during the year: Norman F. Childers, formerly assistant director and plant physiologist, resigned December 15, 1947, to accept the chairmanship of the department of horticulture at Rutgers University, New Brunswick, N. J. Arnaud J. Loustalot was appointed assistant director and plant physiologist on January 11, 1948. Harry E. Warmke, formerly geneticist at the Institute of Tropical Agriculture, Mayaguez, P. R., joined the staff as plant breeder on September 16, 1947. Rubén H. Freyre was transferred from agronomist under insular funds at the station to scientific aid under Federal funds.

There were several changes during the year in the personnel employed on funds provided by the Government of Puerto Rico. José C. Mangual resigned as agronomist on September 2, 1947, to accept a position with the Soil Conservation Service. Pedro Seguinot Robles resigned as agronomist on October 21, 1947. Carlos F. Cernuda resigned as chemist, effective March 2, 1948, to accept a position with the Research and Marketing Act Soil Erosion Control Project at the station. The vacancy was filled by Rafael Fernández Pol on March 3, 1948. Héctor J. Cruzado was appointed to the position of agronomist on October 1, 1947. Narciso Almeyda was appointed to a similar position on April 16, 1948 and Miss Elida Vivas was appointed laboratory technician on November 1, 1947.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The Government of Puerto Rico continued to support certain station activities. The Insular Legislature appropriated funds amounting to $40,000 for the Federal Experiment Station to carry out cooperative experimental work with crops of particular interest to Puerto Rico, including vanilla, spices, weed control, and bamboo.

The experiment station of the University of Puerto Rico and the Federal station continued close cooperation on agricultural problems. Exchange of information through conferences of the directors and members of the staffs of the two stations resulted in a well-coordinated program. Cooperative tomato- and papaya-improvement projects between the two stations were initiated during the year. The Federal station provided office and laboratory space and land facilities for the experimental work with coffee being conducted at Mayaguez by the Insular station.

The College of Agriculture and Mechanic Arts of the University of Puerto Rico, located adjacent to the station, frequently utilized the station facilities in field demonstrations to students. The two agencies also cooperated in the installation of a new sewage line to take care of the needs of both institutions.

The extension service of the University of Puerto Rico extended the finest cooperation to the station in the distribution of plant material, particularly tropical kudzu, bamboo, and USDA–34 sweet corn.

The Federal and Insular Forest Services made labor available to the station for the propagation and distribution of newly introduced bamboos. Several thousand offsets of bamboo were planted on watersheds throughout the mountainous areas of Puerto Rico. The Forest Service continued to make areas of land available at Toro Negro, Maricao, and Guánica, for the testing of various tropical plants and for the cinchona and vegetable programs of the station.

The Puerto Rico Industrial Development Company continued cooperation with the station through the distribution of dried bamboo culms for industrial purposes. The split bamboo fishing rod industry, established 2 years ago, continued to operate successfully, and during the year a new bamboo furniture industry was established.

The cooperative project initiated 3 years ago with the Puerto Rico Agricultural Company in the production of improved varieties of mangos and avocados was continued during the year.

The station cooperated with several bureaus and agencies of the Department. The Bureau of Plant Industry, Soils, and Agricultural Engineering sent O. A. Leonard, of Mississippi State College, to the station to initiate cooperative weed control experiments. The experiments were designed primarily to control nutgrass. Office and laboratory space and land facilities were provided to the Soil Conservation Service, United States Department of Agriculture. Office space, land facilities, and technical assistance were furnished the new Research and Marketing Act Soil Erosion Control Project. Office space was also made available to the Farmers Home Administration and to an Insular plant quarantine inspector, who is a collaborator of the Bureau of Entomology and Plant Quarantine of the Department.

The Bureau of Plant Industry, Soils, and Agricultural Engineering, through its Office of Plant Exploration and Introduction, made available to the station a large quantity of plant material in exchange.

The station cooperated with the United States Department of Agriculture Regional Vegetable Breeding Laboratory at Charleston, S. C., by increasing promising watermelon seed during the winter months, and in testing new tomato selections.

Considerable quantities of planting material were sent to the Office of Foreign Agricultural Relations for introduction and testing at their cooperative experiment stations throughout Latin America. The exchange of information between both organizations was of considerable mutual benefit.

The Mexican Government assigned an agronomist to work at the station for a period of approximately 9 months to study the work in progress on vanilla.

A considerable number of other institutions and agencies, as well as individuals, scattered throughout the tropical world, cooperated with the station in providing plant material to add to the extensive collection of tropical plants.

PHYSICAL PLANT IMPROVEMENT

Seven new staff houses, built under contract, were completed during the fiscal year. The houses are constructed of reinforced concrete and concrete block, and are designed to be earthquake- and hurricane-proof. The design used was prepared through the courtesy and cooperation of the Office of Foreign Agricultural Relations, who assigned Virgil C. Pettit, engineer, to draw the plans and specifications.

A sewage system built in cooperation with the College of Agriculture of the University of Puerto Rico, and of mutual benefit to both institutions, was completed this year. This sewage system connects with the insular disposal system and does away with the use of septic tanks and other methods of sewage disposal.

A large headhouse to service the greenhouse units was nearing completion at the close of the fiscal year. This building is constructed of reinforced concrete and concrete block and will provide ample space for storage and for mixing soil and fertilizers, for potting, and other operations in connection with experimental work being conducted at the station.

INSECTICIDAL-CROP INVESTIGATIONS

Distribution. R. H. Hageman

One hundred and forty-four cuttings of *Derris elliptica* (Wall.) Benth. varieties MG–1 to MG–12, inclusive, were sent to W. R. Lindsay, Summit, Canal Zone. Twelve cuttings of *Lonchocarpus utilis* A. C. Smith and *L. chrysophyllus* Kleinh. were sent, on request, to the New York Botanical Garden. Forty-eight cuttings of *L. utilis* were received from Tingo Maria, Peru, through the cooperation of the Estacion Central de Colonizacion, Tingo Maria, Peru.

Derris Flowering. H. E. Warmke and R. H. Hageman

Three-year-old plants of 10 MG-clones of *Derris elliptica* blossomed early in March 1948. Blossoming continued profusely throughout the month and into the first week of April. Some of these plants were trellised in September 1947 in an attempt to promote flowering. However, flowering occurred among both trellised and untrellised plants to about the same extent. None of the blossoms produced seed. Laboratory observations showed that the pollen grains were regular and well formed, and other observations in the field and laboratory indicated that pollen grains were viable and capable of a high percent of germination. Various attempts to study the causes of the observed sterility were unsuccessful.

Minor Element Studies. R. H. Hageman

Chlorotic plants of *Lonchocarpus chrysophyllus* growing on a well-drained Nipe clay soil were sprayed with a 0.1-percent solution of copper sulfate, a 0.25-percent solution of ferrous sulfate, or a 1.0-percent solution of manganous sulfate. One month after treatment the chlorosis was corrected on the plants sprayed with the copper or the manganese solutions, and vigorous new growth and new leaves were observed on these plants. The plants sprayed with iron solution had stunted and twisted growth terminals, and the chlorosis was more pronounced than before they were sprayed. These preliminary trials indicate that manganese and copper are essential minor elements that are either deficiant or unavailable in Nipe clay soil.

Mulching Derris. R. H. Hageman and C. Pagán

An experiment in which *Derris elliptica* var. Sarawak Creeping was grown for 24 months under four different types of mulches showed that natural mulches of leaves and grass were better than asphalt roofing paper, based on stand of cuttings and yield of roots obtained. The yield of roots under asphalt paper was the lowest and was probably due to the elevated soil temperatures under that type of mulch. The four types of mulches used did not visibly affect the type of root development. There were no significant differences in rotenone, rotenoids, or other toxic constituents in the roots from the four treatments. Ratios calculated between the chemical and biological assays were in good agreement with previous values.

Drying Derris. C. Pagán, R. H. Hageman, and A. J. Loustalot

Derris roots dried in the sun or shade, either split or whole, had a significantly higher toxicity expressed as retonone equivalent than those oven-dried. Since the rotenone content of all samples was

essentially the same, these data would indicate that some substance other than rotenone, that adds to the toxicity of the root, was lost or changed chemically during the period of oven-drying. Although the rotenone equivalent of whole roots dried in the sun was somewhat lower than that of split sun-dried roots or of whole and split roots dried in the shade, the difference was not statistically significant. The red-color values were not markedly different in the roots of the various treatments, although there was some tendency for these values to be higher when the rotenone equivalent was high. There was no statistically significant deviation in the total chloroform extractives of the various treatments. The percentage total chloroform extractives was greater in the roots that were split, irrespective of sun or shade drying, than in those of the other treatments.[1]

Chemical Investigations. C. Pagán and R. H. Hageman

An experiment was conducted in which the relationship of root diameter to toxicity and chemical composition was studied. The results of this experiment showed that MG roots 2 to 4 mm. in diameter were the best in quality, while those 4 to 10 mm. in diameter were the best with respect to yield of roots and toxic constituents. All the roots produced by this variety were of marketable quality. In the Sarawak Creeping variety, diameter group 4 to 10 mm. was the best both in quality and quantity of toxic constituents. Neither the roots less than 2 mm. nor those above 10 mm. in diameter had the minimum rotenone content for marketable roots. Nevertheless, rejecting the thick roots (10 mm. and over) would bring the remaining roots to marketable standard.

A nontoxic compound was found in roots of Sarawak Creeping and MG clones. The compound decomposed without melting at 220° C. It was nontoxic to fish at a concentration five times that of the rotenone standard. It was soluble in HCl and had indicator properties similar to that of an anthocyanin.

Toxicity Studies. C. Pagán

The effect of season and source on the susceptibility of guppies (*Lebistes reticulatus* Peters) to rotenone was studied. The source of the fish was found to be the most important factor in the susceptibility of guppies to rotenone, although the slope of the curve was essentially the same for fish from different sources. Seasonal variations were of lesser importance. The behavior of the guppy population was uniform, and the increase in mortality was the same for a constant percentage increase in dosage of rotenone, regardless of the source of fish or season.

The chemical laboratories used for bio-assaying derris root samples by the "guppy" method were not satisfactory because of chemical fumes and contaminations from derris dust. The interior of an old shed that was previously used for storage was rearranged to provide facilities for making the bio-assay. These new facilities make it possible to assay 36 samples per week, three times the number that could be tested previously. A limiting factor to the number of samples

[1] Pagán, C., Hageman, R. H., and Loustalot, A. J. The effect of sun, shade, and oven-drying on the toxicological and chemical values of derris root. Jour. Agr. Res. [In press.]

that could be assayed at one time was the time and effort required to catch and transport the fish from a creek near Mayaguez, and a stream near Maricao. This problem has been solved by stocking two small ponds on the station grounds with large numbers of guppies.

Other Insecticidal Plants. H. K. Plank

Dusts made from parts of the yam bean plant (*Pachyrhizus erosus* (L.) Urban) were given preliminary laboratory tests for insect toxicity. The ripe fruits and leaves of the local variety were 76 percent and 56 percent toxic, respectively, to *Diaphania*. The remaining parts of *Pachyrhizus*, as well as all parts of *Solanum mammosum* L., were inert or at most only mildly toxic to all species of test insects used. Like all other species and varieties of *Pachyrhizus* thus far tested, the local variety of *P. erosus* was inert to *Cerotoma* adults. Otherwise, it was nearly as toxic as derris, but much less so than pyrethrum flowers and the inorganic poisons.

DRUG-CROP INVESTIGATIONS

Field Studies. H. F. Winters

Additional plantings of *Cinchona*, which include most of the cultivated strains, have been made at Toro Negro during the past 2 years. Survival varied from 7.1 percent to 86.6 percent and was apparently correlated with resistance to *Phytophthora* disease, the principal cause of loss. Survival and growth have been particularly good in progeny from five mature *C. ledgeriana* trees growing at Maricao, and of these the progeny of tree designated as Maricao No. 24 was the best. After 3 years in the field many trees of this strain now stand 10 to 15 feet high. Trees of this strain showed less indication of disease than those in most other strains. Survival was poor in the *C. ledgeriana* from Guatemala, but those surviving are growing satisfactorily and appear to be fairly free of disease.

The poorest results have been obtained with a strain of *C. ledgeriana* from the Philippine Islands. This strain has been particularly susceptible to disease. The results of two small field plantings made in the Maricao Insular Forest show that survival was good, but growth was poor in both plantings. Survival and growth varied considerably among seedlings of 30 *Cinchona* strains which were brought from the Philippine Islands by Fischer and planted at Toro Negro in 1945–46. Some of the hybrid strains showed considerable promise for Puerto Rican conditions, but it is too early to draw conclusions.

Physiological Studies. H. F. Winters and A. J. Loustalot

The results of a nursery experiment with *Cinchona* in which four levels of light and three levels of nitrogen in factorial combination were compared indicate that *Cinchona* seedlings can be grown more or less satisfactorily over a rather wide range of nitrogen and light levels. Growth was somewhat better, though not significantly so, at the higher light levels, particularly when the nitrogen level was also high. Seedlings receiving high nitrogen under full and three-fourths light were the most thrifty, had better color, and were generally stronger than those receiving medium or low nitrogen. Plants supplied with low and medium nitrogen made significantly less growth than those

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supplied with high nitrogen. Leaf color correlated closely with the nitrogen content. Nitrogen content of the leaves increased, as the light level decreased, and this was reflected in darker foliage. The nitrogen content and color of the leaves was also correlated, but to a lesser degree, with the nitrate supply. The rather uniform growth and survival of plants in all treatments may be due in part to the uniform water supply to all plots throughout the experimental period and also to the fact that the young seedlings were protected from the heavy rains that sometimes damage the plants.

Cinchona ledgeriana seedlings were grown in sand culture at three levels of nitrogen (3, 18, and 81 p. p. m.) and three levels of phosphorus (0, 5, and 25 p. p. m.) in factorial combination. The low level of nitrogen had a markedly depressing effect on the growth of the seedlings, but there was no significant difference in the growth of plants receiving 18 and 81 p. p. m. of nitrogen. The high level of phosphorus depressed growth of plants with the low nitrogen supply. The growth was less depressed when a high level of phosphorus was combined with a medium nitrogen level. Growth of the high-nitrogen plants was directly correlated with phosphorus level. Roots and stems of plants grown at the high-nitrogen level contained higher amounts of total alkaloids and quinine sulfate than did those of plants grown at the lower nitrogen levels. There was no consistent effect of phosphorus on the quinine content of the plants in the various treatments, but there was tendency for total alkaloids to be higher in plants with a high phosphorus level.

The nitrogen content of the leaves varied directly with the nitrogen level at which the plants were grown. At all nitrogen levels the nitrogen content of the leaves was inversely correlated with the phosphorus supply. At the low-nitrogen level the high phosphorus concentration accentuated nitrogen deficiency. Leaves of plants grown in the low and medium nitrogen levels contained increased percentages of calcium and phosphorus as the phosphorus supply increased, but the amounts of nitrogen, potassium, and magnesium in these plants decreased.

The results of this experiment indicate that growth of young cinchona trees may be limited under certain conditions if the phosphorus concentration is too high. They also indicate that the phosphorus requirement of cinchona is relatively low and that for optimum growth the phosphorus must be available in the proper proportion to nitrogen and possibly other mineral elements.[2]

CHEMICAL STUDIES. A. J. Loustalot, C. Pagán, and H. F. Winters

An experiment was initiated in June 1946 to study the relationship between size, age, and parts of young *Cinchona* trees and their total alkaloid and quinine content. With some exceptions, the results of the 1947 analyses were similar to those of the previous year. There was no consistent correlation between vigor as measured by height of tree with total alkaloid and quinine content. The percentage of quinine in the roots of the different trees did not vary appreciably, but in the lower trunk bark there was considerable variation in quinine

[2] LOUSTALOT, A. J., and WINTERS, H. F. THE EFFECT OF THREE FACTORIAL LEVELS OF NITROGEN AND PHOSPHORUS ON GROWTH AND COMPOSITION OF CINCHONA LEDGERIANA. Plant Physiol. 23: 343–350, illus. 1948.

content. The highest amount found was 8.1 percent, and the lowest was 2.4 percent quinine sulfate. The upper trunk bark contained consistently more quinine in 1947 than in 1946, and there was a tendency for the amount of quinine in the upper trunk bark to be correlated with that in the lower trunk bark. The amount of quinine in the side branches and wood of the 1947 sample was generally higher than that found in these tissues the previous year.

Nursery Soil Treatments. H. F. Winters

Soil treatment with either D-D mixture or chloropicrin effectively reduced disease in Cinchona nurseries, although D-D mixture has not been found effective against all fungi. D-D mixture was cheaper, easier, and safer to apply than chloropicrin.

An experiment was conducted to compare the effects of media and chloropicrin fumigation in controlling damping-off in cinchona seedbeds. Germination was best in sphagnum moss plots, which had a complete stand of uniformly spaced plants. This was attributed in part to the high moisture-holding capacity of the sphagnum. Germination was also good in the fumigated and nonfumigated soil plots surfaced with sphagnum, but not so good in sphagnum alone. There was no apparent difference after 3 months between treated and nontreated plots in stand or vigor of seedlings. In fumigated soil plots not surfaced with sphagnum, germination was poorest. This is, perhaps, a result of the fumigation, but all traces of the gas had disappeared at the time of seeding. Uniform and good germination was secured in the untreated soil plots. Damping-off started soon after the seeds germinated, and 1 month later the disease had killed from one-fourth to three-fourths of the seedlings in these plots. The disease was not present in treated plots.

Cinchona Grafting. H. F. Winters

Attempts to graft *Cinchona* to six closely related tree species have been unsuccessful. The results with two species, *Exostema sanctaeluciae* (Kentish) Britten, and *Rondeletia portoricensis* Krug and Urban, were more promising than the others. With these species the scions lived for a considerable time. Attempts to propagate these two species by hardwood cuttings resulted in a very low percentage rooting. For later grafting trials seedlings of these species were collected in the forest and interplanted with seedlings of *C. ledgeriana* and *C. succirubra*. When sufficient growth had been made the plants were grafted by inarching to the rootstock seedlings. In none of the trials was a union formed between stock and scion. It would seem, therefore, that *Cinchona* is highly incompatible with these native rubiaceous species, and trials will be discontinued.

Cinchona Insects. H. K. Plank and H. F. Winters

Light infestations of (*Heliothrips haemorrhoidalis* (Bouché)) (greenhouse thrips), (*Tryphactothrips angulatus* (Hd.)), and *Dinurothrips hookeri* Hd. on 4-year-old *Cinchona ledgeriana* trees at Toro Negro were controlled without injury by spraying once with 25-percent wettable DDT at the rate of 4 pounds in 100 gallons of water. Two-year-old, 24-inch seedlings growing in the open withstood three applications of this same spray, but 2-inch seedlings were severely injured

and 14-inch rooted cuttings had some leaves burned by one applications under greenhouse conditions.[3] Large nymphs of *Periplaneta americana* (L.) (American cockroach) were a pest of freshly planted seed and the nymphs of the cricket, *Anurogryllus nuticus* (Deg.), and the larvae of an unidentified pyralid moth damaged small plants in the greenhouse. The first were controlled with phosphorus paste and the last two by hand picking.[3]

FOOD-CROP INVESTIGATIONS

Vegetable Trials. N. F. Childers, H. F. Winters, P. Seguinot Robles, and H. K. Plank

Vegetable trials were continued this year to obtain additional information on those crops which previously appeared best adapted to the spring and summer season at Mayaguez and Toro Negro. In some cases limited variety trials were also included. Trials at Maricao had to be discontinued due to a reduced labor staff. Results with vegetables planted in March 1947 and harvested during the next 5 months at Mayaguez showed that the vegetables performing satisfactorily during this period were: Broccoli, cabbage, cauliflower, collards, cucumber, eggplant, Slobolt leaf lettuce, kale, mustard, okra, green onion, parsley, pepper, radish, New Zealand spinach, Swiss chard, and tomato of the varieties WST–13–2, Pritchard, and Grothen Globe.

Vegetables performing poorly during this period were: Beet (poor seed), carrot (poor seed), endive, leek, pea, rhubarb, turnip, and watermelon. Continued use of DDT was highly effective in insect control, particularly against *Plutella maculipennis* (Curt.), diamondback moth, on cole crops. Some leaf injury, apparently due to drift of DDT, was observed on cucurbits. It was of interest to note that one of the improved varieties of tomato, WST–13–2, from the Southern Regional Vegetable Breeding Laboratory, Charleston, S. C., gave the highest yield of uniformly large fruits under Mayaguez conditions. This variety appeared to be definitely more resistant to leaf diseases than standard varieties ordinarily grown under Puerto Rican conditions; it appears to be good breeding stock for development of improved tomato varieties for the Tropics.

Results with vegetables planted at Toro Negro in March and April 1947 and harvested during the summer months showed that all the vegetables planted gave satisfactory results, including the only two that had not been tried previously, salsify and New Zealand spinach. In most cases development was somewhat slower than in previous plantings. This could be attributed to an unusually dry spring and summer. Of the six varieties of cabbage tested, All Seasons, Early Jersey Wakefield, and Succession gave the best results. Other varieties either gave small heads or failed to head. Danvers Half Long carrot proved to be the best variety for the Toro Negro section. This variety was more resistant to foliage blight than the others tried. Purple Top White Globe turnip proved superior to Golden Ball.[4]

[3] Plank, H. K., and Winters, H. F. insects and other animal pests of cinchona and their control in puerto rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 46: 16, illus. 1949.

[4] Childers, N. F., Winters, H. F., Seguinot Robles, P., and Plank, H. K. vegetable gardening in the tropics. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. [In preparation.]

Tomato breeding. H. E. Warmke and H. J. Cruzado

Three imported tomato varieties (Marglobe, Michigan State Forcing, and an unnamed USDA selection), two native tomatoes (Platillo and Kaneko), and seven hybrids between native and imported varieties were compared in yield trials. The four best F_1 hybrids, those involving an imported variety crossed by Kaneko, were significantly better than the Kaneko parent or any of the imported varieties tested. The best hybrid (47387) significantly outyielded all pure lines, whether imported or native. All other lines tested significantly outyielded the native Kaneko. The Kaneko, although doing very poorly as a pure line, was a better combiner in hybrids than was the Platillo tomato. The fruit shape of the commercial varieties is largely dominant over the highly ridged and cat-faced fruits of the native tomatoes. F_1 hybrid fruits in the better hybrids are scarcely distinguishable from the standard varieties and, therefore, are acceptable in the market. Preliminary chemical analyses indicate that pH, total titratable acidity, and solids of the hybrid lines do not differ in any important respects from the standard varieties. Experiments are now being made in an effort to produce and further test various promising combinations, with the purpose of determining whether hybrid seed can be produced profitably for growing these hybrids on a commercial scale.

The station has recently entered into a cooperative tomato improvement program with the experiment station of the University of Puerto Rico. The objective of this cooperation is to introduce into the standard commercial varieties, genes that are present in the native Platillo and Kaneko varieties and that are tolerant to heat, stimulate fruit setting, and build up disease resistance; and to stabilize these genes in these commercial varieties. Eighty-three F_3 selections from commercial and native tomato crosses produced an average of 2.17 pounds of marketable fruit per plant, or about 2.5 times the yield of the commercial check variety (Rutgers, 0.86 pound per plant). Only 3 of the 83 hybrid lines, 47324 (0.44 pound), 47362 (0.70 pound), and 47331 (0.77 pound) produced less fruit per plant than Rutgers. The 3 highest yielders among the hybrids, 47368 (4.62 pounds), 47284 (4.25 pounds), and 47366 (4.17 pounds) produced an average of slightly over 5 pounds of fruit for each pound produced by Rutgers. The hybrid lines showed up equally well in the trials at the Isabela station of the University of Puerto Rico Experiment Station, where they were compared with Pearson, Penheart, Marglobe, and Rutgers. Many of the hybrids still show segregation for the poor fruit quality and irregular fruit shape of the native tomatoes. These undesirable characteristics, however, can be eliminated by selection, and the increased yields of the crossed lines indicate that the desirable characters of the native tomatoes are being retained.

STEP Trials. H. E. Warmke, H. J. Cruzado, and N. F. Childers

STEP (Southern Tomato Exchange Program) tomato breeding trials were conducted again this year in cooperation with the Southern Regional Vegetable Breeding Laboratory. These trials included 43 experimental lines and 4 standard varieties. All plants in this group of trials were unusually healthy and were attacked to only a minor degree by the usual diseases. The set of fruit after blossom time, however,

was poor and resulted in mediocre yields. Some of the selections, such as STEP-54, STEP-50, and STEP-74, however, showed sufficient promise to warrant their being included as breeding stocks. STEP-64 was clearly the earliest producer of the group.

SWEETPOTATO BREEDING. H. E. Warmke, H. J. Cruzado, and E. Vivas

Thirteen out of 16 sweetpotato varieties planted at Mayaguez in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering produced flowers.[5] These plants were set in field plots in July, trained up on trellises, and kept thinned by constant pruning, following the methods recommended by Miller. Two of the difficult Jersey-type varieties, Orange Little Stem and Maryland Golden, were included in the group. Orange Little Stem produced blossoms over a period of 6 weeks and set some open-pollinated seed. One hundred and fifty-three crosses were made, using moist-flesh varieties as female parents and Orange Little Stem as pollen parent. Of these, six or 3.9 percent, were successful. The six included crosses between U.P.R.–3, Don Juan, Mameya, B–5928, and the Jersey variety, Orange Little Stem.

Crosses were made among moist-flesh varieties as well as with the Jersey types in order to gain as much information as possible regarding the efficacy of methods, timing of pollinations, and fertility of varieties. Of a total of 645 crosses made, 23, or 3.6 percent, were successful and set fruits. Although this percentage is low, it may not be too low when it is considered that the crosses were made outdoors, and that these figures include 217 crosses made, using the wild species, *Ipomaea tiliacea*, as pollen parent, which appears not to be cross-fertile with *I. batatas*.

MANGO VARIETY STUDIES. E. P. Hume and R. H. Freyre

A new planting of mangos (*Mangifera indica* L.) consisting of one or two trees of 47 varieties has been planted at Los Perros. When additional land becomes available more representatives of each variety will be added to take the place of the present orchards which are overcrowded and poorly drained.

A planting in the introduction area at Las Mesas of one or two trees of 31 varieties of avocados (*Persea americana* Mill.), consisting of new introductions and some from a former cooperative planting at Guayanilla, has been completed.

Mango and avocado grafting experiments.—The results of a mango-grafting experiment on 2-year-old seedlings showed that side tongue grafting on intact stocks was better than cleft, fit cleft, bark, or top tongue grafting on cut-back stock.

A program for providing grafted mango and avocado trees was carried out in cooperation with the Puerto Rico Agricultural Company over the past 2 years. The station utilized the project for experimental work on propagation methods to prepare the plants necessary for an experiment on stock-scion compatibility and to secure grafted plants for the varietal and cultural trials described above. The Puerto Rico Agricultural Company secured 1,814 established, grafted mangos, 489 mango seedlings, and 713 grafted avocados.

[5] WARMKE, H. E., and CRUZADO, H. J. THE FLOWERING AND SEED SETTING OF SWEETPOTATOES IN PUERTO RICO. Science 109: 62–63. 1949.

A comparison of growth and stand of avocados planted with and without seed coats was made. The average height of the seedlings planted without seed coats after 2 months was 13.1 inches as compared with 11.2 inches for those planted with seed coats. The germination of seeds without seed coats was 96.4 percent as compared with 84 percent for those with the seed coat.

An experiment was conducted to compare side grafting on very young avocado stocks with other methods of avocado propagation recommended in Florida and Puerto Rico. Better results were obtained with shield budding than with the other methods when the scion buds were swelling. No advantage was found when using tongue grafts over simple side grafts with young stock plants. The cleft graft, even with young stock, was unsatisfactory under the conditions of this experiment.

MANGOSTEEN STUDIES. E. P. Hume and A. J. Loustalot

Root formation was stimulated in mangosteen seedlings treated with indolebutyric acid. There was a slight reduction in top growth from the treatment. The average dry weight of new roots produced on treated seedlings was 9.1 grams, compared with 5.5 grams on check trees. Presumably better top growth and a more vigorous tree will develop from plants with a superior root system.

ROOTING EXPERIMENTS. E. P. Hume

An experiment was conducted to determine the possibility of propagating superior types of eight kinds of tropical fruits by cuttings. The species selected for this study were: Avocado (*Persea americana* Mill.), West Indian cherry (*Malpighia glabra* L.), Ceylon gooseberry (*Dovyalis hebecarpa* Warb.), "corazón" (*Annona reticulata* L.), "guanábana" (*A. muricata* L.), guava (*Psidium guajava* L.), lichee (*Litchi chinensis* Sonn.), and mango (*Mangifera indica* L.).

The West Indian cherry and Ceylon gooseberry cuttings rooted successfully, but no success was obtained with rooting the avocado, bullock's-heart, soursop, or mango. Only a single lichee and a single guava cutting rooted. By far the greatest rooting occurred in an enclosed case, where leaves remained green longer and new shoots developed. No benefit was obtained by subirrigation or fertilization. Apparently equal results were obtained from terminal, leafy, and hormone-dipped hardwood cuttings. About half the number of untreated hardwood cuttings rooted.

SEED INCREASE. H. E. Warmke and H. J. Cruzado

At the request of B. L. Wade and C. F. Andrus of the Regional Vegetable Breeding Laboratory at Charleston, S. C., the Federal Experiment Station in Puerto Rico undertook to increase, during the winter season, the seed of a new and valuable watermelon selection (46–40) that had been developed by the Charleston Laboratory for the Southern States. One hundred grams of this special seed were received on October 25 and were planted October 30. The first harvest was made February 17 and consisted of 70 melons, ranging in size from 10 to 20 pounds. The second harvest was made February 28 and consisted of approximately 50 melons, of a size somewhat smaller than those in the first harvest. The melons were oblong,

with dark green stripes and a tough rind. They were of uniformly high quality, ripened evenly, and had a high sugar content. A total of 4,000 grams of seed, or an increase of fortyfold over the original 100 grams, was obtained. This was sent to the Charleston Laboratory on March 22, in time for spring distribution to the southern cooperating stations.

PLANT INTRODUCTION AND PROPAGATION

DISTRIBUTIONS. E. P. Hume and R. H. Freyre

A total of 251 seed packages was distributed to 25 countries. In addition, the following special items were distributed for propagation: 131 square feet of *Zoysia matrella* (L.) Merr., 44 pounds of cuttings of essential oil plants; 3.2 pounds of yams, *Dioscorea* sp.; 60 pounds of USDA–34 sweet corn, *Zea mays* L.; and 227 pounds of ginger rhizomes, *Zingiber officinalis* Roscoe, and other species. The plant distributions for Puerto Rico included 21,150 ornamentals and 395 fruit trees.

The pharmacological properties of the dumb plant, *Dieffenbachia seguine* (L.) Schott, a native of Puerto Rico, have recently become of interest at two medical schools in the United States. Almost 200 pounds of both fresh and dried material of this species have been gathered, prepared, and sent to these institutions for study.

Tremendous interest in tropical kudzu, *Pueraria phaseoloides* (Roxb.) Benth., was aroused by the paper of Telford and Childers on the value of this legume for the Tropics. Requests for seed and additional information have been received from more than 25 countries.

INTRODUCTIONS. E. P. Hume and R. H. Freyre

Seeds and plant parts for propagation, totaling more than 422 accessions, were received from 20 countries and 9 States and Territories. The largest group was the grass and legume cover crop group, totaling 171 accessions, which have been requested from many sources as material for breeding projects. In some cases these include different strains of the same species and several accessions of one species from different localities. There were, in addition, 156 ornamentals, 72 fruit, and 23 miscellaneous economic species. Among the more important fruit accessions were the green sapote, *Calocarpum viride* Pittier, a species from Guatemala which may serve as a fruit crop for higher elevations in Puerto Rico; 3 new *Diospyros;* 2 *Flacourtia;* 2 *Spondias;* 3 superior guavas; and a collection of 6 better *Citrus* varieties.

SEED STORAGE. N. Almeyda and E. P. Hume

Germination tests were made on 160 species of seeds stored in jars over lime or calcium chloride at room temperature. This included all species that were available in sufficient numbers for testing. Germination was particularly low in hard-coated seeds, even when they were chemically scarified. Thirty-four species were scarified, only 12 of which germinated, and the maximum germination was 20 percent. These results indicate that many of the seeds for exchange have a much shorter storage life at room temperature than was thought. Seeds with extremely short storage life will no longer be stored, but will be supplied only at the time of ripening to those requesting seeds during the year.

Tropical Kudzu Investigations. E. P. Hume and E. A. Telford [6]

Several fertilizer treatments were applied to tropical kudzu seedlings growing on Nipe clay soil. Examination of the seedlings 6 weeks later showed that no benefit was derived from applications of potassium sulfate or lime screenings, either alone or in combination. On the other hand, plots that received phosphate applications were outstanding, as indicated by the vigorous growth of both kudzu and weeds. Very little chlorosis was observed on phosphate-treated plots; whereas plots fertilized with potassium showed interveinal chlorosis. Limed plots produced leaves with a uniform light-green color. The chlorosis on the check plots was similar but not as pronounced as that on the plots fertilized with potassium. Preliminary studies of seeding methods and fertilizer application indicated that better stands were obtained when the seeds were either covered or lightly mulched than when they were not protected. Firming the seeds by walking on them was of no particular value if they were mulched or covered. Trenching fertilizer 2 to 3 inches below the seeds had not improved their growth over the checks 6 weeks after seeding, but after 12 weeks of growth the fertilized seed was better than the checks.

Tropical kudzu was grown in 10-gallon glazed jars at three elevations, Maricao (2,600 feet), Toro Negro (3,300 feet), and Mayaguez (sea level). After 1 year the kudzu at Maricao and Toro Negro had made limited growth and most of the plants were dead. Those at Mayaguez grew vigorously, and at present the vines are large, thrifty, and overflow the crocks. Since the soil type, fertility, and moisture at each location was practically the same, it appears that the cooler temperature of the uplands is an important factor in the slower growth of this legume at higher elevations. However, experience has shown that when tropical kudzu becomes established in the uplands it does eventually make a good cover, and grows about as satisfactorily as any legume tested in these areas.

Manila Grass Fertilization. E. P. Hume

Previous trials have shown that plugs of Manila grass (*Zoysia matrella* (L.) Merr.) cannot successfully compete with vigorous carpet grass (*Axonopus compressus* (Sw.) Beauv.). A preliminary trial was undertaken to determine the amount of ammonium sulfate required to burn out the carpet grass without excessive injury to the Manila grass. The results indicated that 1 ton per acre, and probably more, would be required, since any surviving carpet grass is greatly stimulated by the fertilizer. Manila grass was occasionally slightly injured at the ton rate.

Manila Grass Seed Germination Experiments. R. H. Hageman

Germination tests with Manila grass indicated that most of the nonviable seed could be removed by water flotation. The addition of wetting agents to the water was of no apparent benefit. Hand winnowing did not effectively separate the seed. Microscopic examination of the endosperm and embryo of the Manila grass seed verified the germination tests of the two fractions obtained by the water separation. The endosperm and embryo of the seeds that sank

[6] USDA Soil Conservation Service, now with Bureau of Plant Industry, Soils, and Agricultural Engineering.

were well developed, while those in the seeds that floated were poorly developed or entirely missing. A limiting factor in establishing a Manila grass lawn from seed is the lack of viable seed. This experiment shows that water flotation is a simple, efficient means of separating the well-filled seed.

Pretreating unselected Manila grass seeds with either 2,4–D, acetic acid, formic acid, or potassium hydroxide solutions significantly increased the percentage germination over that of the controls. Three methods of scarification, sand blasting, passing through a Wiley mill, and crushing with an iron roller, failed to improve germination.

Manila grass seed stored at 100 percent humidity for a period of 3 months had much lower viability than seed stored over sulfuric acid at 50 and 75 percent humidities. Seed stored at approximately 25 and 0 percent humidities germinated poorly, possibly because of toxic fumes from the concentrated sulfuric acid.

Germination tests were made on Manila grass seed stored in a paper bag in the laboratory for 1 year. The seeds were separated by water flotation, and the heavy fraction subjected to various chemical treatments. The percentage germination of all treated seed was less, but not significantly so, than that of the control. Seventeen percent of the control seeds germinated, compared to 50 percent germination obtained with freshly harvested heavy seeds in a previous experiment. This indicated that the seeds used in the present experiment deteriorated under the long and unfavorable storage.

Coco Peat Analysis. R. Fernández and A. J. Loustalot

Chemical analyses of samples of fresh coco peat showed that the mineral content was relatively low, particularly with respect to nitrogen and phosphorus. The fact that coco peat contains less than 1 percent of any of the major nutrient elements indicates that it has little fertilizer value. The beneficial qualities of coco peat apparently are due to its ability to hold moisture, permit adequate aeration, and provide favorable physical conditions for root development. The pH of coco peat extract ranged from 5.7 to 6.7.

Weed Control. A. J. Loustalot and R. Ferrer Delgado

There was no statistically significant difference in yield of sugarcane among plots receiving 10 different weed control treatments. The hand-hoed plots had the highest average yield. The cost of weed control in the various treatments varied from $21.26 per acre in the case of Penite 6 to $66.42 per acre for Dow Contact. Although the Penite 6 was the cheapest herbicide tested, it gave good control of both annual and perennial weeds, but it has the disadvantage of being poisonous, irritating to the workers, and may accumulate in toxic amounts in the soil. The 2,4–D, on the other hand, has none of these disadvantages, but it is specific for broadleafed type weeds only. There is a danger that continued use of this material may result in heavy stands of hard-to-eradicate grasses.

A weed-control program in which 2,4–D occasionally is used with a general herbicide, such as oil and Santophen or dinitro compounds, may be the most economical and most efficient in the long run. From a weed control standpoint, the Dow Contact was the most effective herbicide tested in this experiment, but it was also the

most expensive ($66.46 compared to $42.04 per acre for the check or hand-hoed plots).

When special "low volume" spray nozzles were used to apply 2,4–D solutions, one man covered an acre in a little over 1 hour. Where 1½ pints of 2,4–D butyl ester in 5 gallons of water were used, 10 gallons of solution was needed to cover an acre, and the cost of materials was $4.50. On the other hand, where 1 pint of 2,4–D butyl ester in 3 gallons of Diesel oil was used, the cost of materials to spray an acre was only $1.89, and only 3 gallons of spray solution were used. However, the weed suppression in this case was not as effective as with 2,4–D in water. When ordinary nozzles are used, about 100 to 125 gallons of 2,4–D (0.1 percent sodium salt) and about 10 man-hours are required to cover an acre.

Ethylene dibromide was far superior to chloropicrin in controlling nutgrass. It was almost as effective when applied at the rate of 6 ml. per square foot as at 12 ml. per square foot. These plots were practically free of nutgrass and were covered with "verdolaga," *Portulaca oleracea* L., about 2 months after treatment. The plots treated with ethylene dibromide at 3 ml. per square foot had a solid stand of nutgrass and were indistinguishable from the check plots. Plots in which 3, 6, and 12 cc. of chloropicrin per square foot were applied all had a luxuriant stand of nutgrass, indicating that this fumigant not only failed to control the nutgrass but rather stimulated the growth.

Although the ethylene dibromide applied at 6 and 12 ml. per square foot gave excellent control of nutgrass, this treatment does not appear practical for large-scale use because of the expense involved. The cost of the fumigant alone at the 6 ml. per square foot rate would amount to about $495 per acre. The cost of labor required for application would also be considerable. Unless the cost of ethylene dibromide is reduced appreciably, the use of this fumigant for controlling nutgrass is limited to small areas like seed or nursery beds and small garden plots.

Sodium trichloroacetate, applied at 218 pounds per acre, was also effective in controlling nutgrass. There was no significant difference between plots in which the chemical was applied in split applications with disking and those in which it was applied in one application to the undisturbed soil. The plots on which 2–4–5 trichlorophenoxy acetic acid was applied at 5 pounds per acre, either on disked or undisked soil, appeared no different from the check plots, which had heavy stands of nutgrass and other weeds. Before sodium trichloroacetate can be recommended as a practical means of controlling nutgrass, considerable experimental work will be required to determine the minimum effective rates of application under different climatic conditions and the length of time required before crops can be planted on treated soil.

An experiment was conducted in which 10 pre-emergence weed control treatments were compared. Corn, Centrosema, pigeonpeas, and squash were grown as the test crops. Santobrite applied at the rate of 30 pounds per acre gave the best results. The weed control in these plots was excellent and there was no adverse effect on any of the crops tested. Santophen at the same rate had no effect on the

crops but did not control the weeds. Dow Contact either at 6 or 12 gallons per acre as a pre-emergence spray had no noticable effect on the crops and, likewise, did not effectively control the weeds. 2,4–D alone at 1.3 pounds per acre had no appreciable effect on nutgrass or Bermuda grass, but did control the broad-leaf types fairly well. At 2.6 pounds and 5.2 pounds per acre the 2,4–D not only controlled the broad-leaf plants but controlled Bermuda and other grasses, and also suppressed nutgrass to a certain extent.

The addition of IPC, particularly at the higher rates, appeared to have a beneficial effect in reducing the infestation of Bermuda and other grasses. The crops, particularly the Centrosema, pigeonpeas, and squash, were affected adversely by all 2,4–D applications.

These results are considered as indicative rather than conclusive because of their limited value in terms of weather, soil, and crop variation. An attempt to control nutgrass with a combination of 2,4–D applications and tillage, followed by a smother crop, was unsuccessful.

ENTOMOLOGY

Parasite Distributions. H. K. Plank and K. A. Bartlett

At the request of W. R. Thompson, Director of the Commonwealth Bureau of Biological Control, Bellville, Ontario, Can., a shipment of *Egius platycephalus* Muls. and *Chilocorus cacti* (L.) was sent to Paget, Bermuda, for trial against a scale infesting Bermuda Cedar (*Juniperus bermudiana* Linn.). The predators were collected in the vicinity of Mayaguez and Isabela. *E. platycephalus* was collected largely on bamboo, where the adults were feeding on *Asterolecanium miliaris* (Bdv. C.). *C. cacti* was collected on the same scale and on papaya, where the adults were feeding on the white peach scale (*Pseudaulacaspis pentagona* (Targ.)). The shipment consisted of 1,050 *E. platycephalus* and 320 *C. cacti*. The only report received concerning their condition on arrival was that the shipment arrived in good condition and that 315 of the *C. cacti* were received alive.

DDT Trials. H. K. Plank

The field trial of DDT against bean insects, previously reported, was continued during the latter part of the following dry season and compared with a commercial rotenone-pyrethrum concentrate. All plots sprayed with DDT were free of mosaic, while those not so treated were uniformly infested with this disease. This condition was believed to be attributable to the control of leafhoppers in the DDT plots. There was a tendency for both DDT and rotenone-pyrethrum to reduce production below that of the untreated plots, but such reduction was not statistically significant. Approximately 4,000 pounds of green beans per acre in the first harvest and a total of 10,000 pounds per acre for the season is believed to compare favorably with yields in other locations. Both treatments failed to control infestation by the pod borers, *Maruca testulalis* (Geyer) and *Etiella zinckenella* (Treitschke), but good control of certain other insects was obtained. The use of DDT in this experiment resulted in highly significant reduction in population of three important bean pests, leafhoppers, thrips, and lacebugs, but such control was not reflected in crop yields. Neither DDT nor rotenone extract or rote-

none-pyrethrum concentrate was effective against pod borers, leaf beetles, and mites. The addition of sulfur to the DDT spray materially improved the control of mites.

The lasting qualities of DDT as a treatment for *Dinoderus minutus* (F.) (bamboo powder-post beetle) in harvested bamboo were tested in a large scale experiment in which Diesel fuel oil was used as the solvent, instead of kerosene, and application was by dipping, instead of brushing, as in a previously reported experiment. Examination made 6 months after treatment showed that among the freshly harvested culms treated with DDT, 96 percent fewer internodes were beetle infested than among the untreated. Clump curing previous to treatment with DDT did not improve control. Diesel oil solvent had little effect by itself, reducing beetle infestation only 7 percent among the freshly harvested pieces and 13 percent among the clump-cured. The high percentage of control still being maintained by 5-percent DDT, as here formulated and applied, indicates outstanding usefulness of this material for the protection of bamboo wood against the powder-post beetle.

SOIL EROSION CONTROL AND STABLE CROP PRODUCTION IN PUERTO RICO

Legume Testing. H. E. Warmke and R. H. Freyre

Preliminary results were obtained in an experiment in which forage production, nitrogen fixation, and chemical composition of five superior legumes growing in combination with Merker grass, *Pennisetum purpureum* Schum. var. *merkerii*, are being compared. No difference in nitrogen fixation among the various legumes was evident at the time of first harvest, but significantly more total forage was produced on plots containing grass-legume combinations than from plots with grass alone. To date, the red bean *Canavalia* sp. has been the most productive legume. Root-nodule counts, made at 3 and 6 months after planting, indicate that the red bean and Florida velvet-bean nodulated earlier and better than tropical kudzu or cowpea.

Legume Breeding. H. E. Warmke, R. H. Freyre, and E. Vivas

An improved emasculation and crossing technique, similar in many respects to that used in alfalfa crossing in the continental United States, has been adapted for use with tropical kudzu. By cutting all petals near the base the day before flower opening and immersing the stigmas and already opened anthers in a 57-percent alcohol solution for a second or two, and then for a similar period of time in water, complete failure of seed setting was found to result. This indicated effective emasculation. When such alcohol-treated stigmas, after allowing time for complete drying, were pollinated with kudzu pollen, using sandpaper-tipped toothpicks as applicators, a 17-percent set was achieved. This indicated that the receptivity of the stigmas had not been destroyed by the alcohol. Since untreated self- or open-pollinated flowers on the same plant (toward the close of flowering period) set only 8 percent, the 17-percent set for manual pollination was considered favorable.

A segregant of tropical kudzu, bearing considerably less pubescence on stems and petioles (designated hairless), has been discovered in

the pasture plantings of the south field. This new type has been selfed and back-crossed to the normal hairy parent, and F_1 progenies are now growing in field plots. Hairless plants, when selfed, produced offspring showing some variation in hairiness but, in general, similar to the hairless type; when crossed back to the normal hairy type, they produced normal hairy offspring. These observations would indicate that the hairless character is genetic and probably recessive in nature. Seed of the mutant is being increased, and tests are being planned to determine its productivity and palatability. It is expected that the reduction in number of hairs on stems and petioles may render the hairless selection more palatable than the normal tropical kudzu.

Interspecific hybridizations have been made, in all combinations, among three *Stizolobium* species, *S. deeringianum* Bort. (Florida velvetbean), *S. pruritum* (Wight) Piper and Tracy (pica pica), and *S. aterrimum* Piper and Tracy (Bengal bean). From the standpoint of a forage legume for Puerto Rico, each of these species has desirable characteristics, as well as certain undesirable ones. It is hoped that from these combinations, selections may be made retaining the yield and forage qualities of the velvetbean, but having more hardy and persistent growth and a longer vegetative period. The hybrids are now being grown in field plots, where their forage characteristics, morphology, cytology, and fertility will be investigated.

Soil and Agronomic Experiments. R. M. Smith, E. A. Telford, C. F. Cernuda, J. R. Hernández, and P. F. Tirado [7]

Preliminary trials in the Utuado area have shown that tobacco can be grown on very steep slopes without erosion if sod or trash and proper fertility and management are provided. Both field and greenhouse studies have indicated that Utuado subsoil is productive if properly treated. Sulfur deficiency has been definitely detected in velvetbeans growing in the greenhouse on Utuado and Múcara subsoils. Lime and phosphorus treatment has resulted in definite improvement of hill-land dairy pastures in 6 months and of newly seeded kudzu on eroded red clay subsoil in 2 months. Fertilization with nitrogen has resulted in an increased grass density and growth on poor upland native pastures within 3 months after application. Lime and other fertilizers have shown little influence in this time. Soil organic matter determinations indicate that grass and legume covers have built as much as 3 percent organic matter into the 0- to 1½-inch layer of Catalina clay on old bench terraces in 8 years.

VANILLA

Agronomic Experiments. H. R. Cibes and N. F. Childers

A well-replicated experiment was started in 1944 in which vanilla was grown under two degrees of shade (½ and ⅓) with three types of mulch (Toa, Soller, and Catalina) and two levels of limestone. The growth measurements made after 18 months showed that Toa mulch without limestone produced significantly larger vines than Catalina mulch alone or Soller, Toa, and Catalina mulch with limestone.

[7] Personnel employed under RMA project 57, SCS–BPISAE, in cooperation with the Experiment Station of the University of Puerto Rico.

Growth was not significantly better than that obtained with Soller mulch without limestone. Up to that time Toa and Soller mulches without limestone resulted in the best vegetative growth.

There was no significant difference between light treatments and no significant interaction between light and mulches, with or without limestone. The vines flowered for the first time in the winter and spring of 1946–47, 3 years after planting. Approximately 50 percent of the flowers were pollinated, and the first crop was harvested in the winter and spring of 1947–48. A statistical analyis of this data showed, as was previously found for vegetative growth, that there was no significant difference between light treatments, and also that there was no significant interaction between light and mulches. However, the fact that there was less sunburn injury, and probably less loss of soil moisture during the dry season, under the one-third light treatment would recommend it over the one-half light.

There were statistically significant differences in yield of vanilla plants growing in the three types of mulch. Toa mulch with limestone produced higher yields than Catalina with or without limestone and Soller with limestone, but not significantly better than Toa and Soller without limestone. Toa mulch without limestone yielded significantly more beans than Catalina with or without limestone and Soller with limestone. Toa mulch with or without limestone resulted in the best production. Approximately 20 percent of the crop was affected by the blast disease, caused by *Phytophthora jatrophae* Jens., and had to be discarded. This disease affects both vines and fruit. The leaves and stems gradually wither and die, and the beans are rendered unmarketable. Ten of the badly infested beds (one twenty-fifth of the planted area) produced no fruit, but in spite of this setback the yield of fresh beans for the entire experimental area (one-third of an acre) amounted to 419 pounds, or over 1,200 pounds per acre. A yield of 500 pounds per acre in Puerto Rico is considered good. The vines in all treatments flowered profusely in the current season, and the 1948 crop should greatly exceed that of last year.[8]

The good growth and fruiting of vanilla under the lath-shade experiment formed the basis of a cooperative experiment established in June 1947 between the Federal Experiment Station and the Mayaguez Tropical Products Company, located near Maricao, P. R. The experiment involved a comparison of three treatments each covering about one-half acre: (1) Vanilla grown on a 45-percent slope on terraces 4 to 5 feet wide and about 200 feet long for which shade is provided by old established coffee shade trees of pomarrosa, *Eugenia jambos* Linn., thinned to admit about 50 percent sunlight; (2) vanilla grown on a 30-percent slope in continuous beds located on terraces 4 to 6 feet wide (bamboo lath spaced to admit about 50 percent sunlight); (3) vanilla grown on a 30-percent slope on individual terraces each about 3 feet across, 8 to 10 feet apart, with rows arranged on the contour, and for which shade is provided as in (1).

Net returns per treatment will be determined over a 5- to 10-year period or longer, depending upon how long the vanilla is productive. This experiment should give Puerto Rican vanilla growers valuable

[8] CIBES, H. R. THE LATH-HOUSE METHOD FOR GROWING VANILLA IN PUERTO RICO. [In preparation for the *Revista de Agricultura de Puerto Rico.*]

information on yields under three distinct methods of growing vanilla and the net returns from each.

Past experience in Puerto Rico indicates that there is a close correlation between vanilla production and the amount and regularity of rainfall. Trial vanilla plantings were made in several parts of the island differing widely in rainfall and altitude. One planting was made on the north coast near Arecibo, at sea level. The annual rainfall for this region is about 65 inches. Periodic inspections of these plantings showed that the vanilla was growing slowly but satisfactorily during the first 6 months. An inspection made 6 months later, after a severe drought, showed that many of the cuttings were dead, badly wilted, or making poor growth. A long drought for this region is unusual, but it clearly shows the importance of rainfall in commercial vanilla plantings and indicates the need for irrigation in areas where such droughts are likely to occur.

Another planting was made at the U. S. Tropical Forest Experiment Station, at El Yunque, on the northeast coast. The elevation of this location is 1,800 feet with an annual rainfall of about 150 inches. An inspection of this planting a year after it was made showed that the vanilla cuttings were growing vigorously and practically all of them were alive, although many were suffering from attacks of snails and slugs. The climate in this location appears to be well suited to vanilla production. Another planting was made at Toro Negro, which has an elevation of 3,300 ft. and receives an annual rainfall of about 100 inches. One year after planting the survival of vanilla vines in this area was good but growth was slow, due either to a cooler temperature or too much shade. There was no indication of death, wilting, or missing plants due to low soil moisture. All plants were turgid and had good color. *Vanilla eggersii* Rolfe and *V. barbellata* Reichb. f. were making the poorest growth, whereas *V. fragrans* (Salisb.) Ames, *V. pompona* Schiede, and *V. phaeantha* Reichb. f. were making the best. This location appears favorable for growing vanilla, but growth may not be as rapid as at lower altitudes.

PHYSIOLOGICAL STUDIES. H. R. Cibes, C. Cernuda, and A. J. Loustalot

Vanilla vines were grown in gravel culture with three levels of nitrogen (3, 10, and 81 p. p. m.) and three levels of potassium (0, 7, and 40 p. p. m.), in factorial combination. An increase in the level of either nitrogen or potassium resulted in an increase in the growth of the vines. The best growth was obtained under the highest N-K level. Plants receiving low nitrogen appeared chlorotic, and plants receiving high nitrogen had dark green color, while those receiving medium nitrogen were intermediate. There was no apparent effect of potassium on foliage color.

Leaf samples from vanilla plants growing under different experimental conditions in the lath-shade experiment were analyzed for ash, calcium, magnesium, potassium, phosphorus, and nitrogen.

The ash content of leaves from plants growing in Soller mulch without limestone was the lowest of any of the treatments, but when limestone was added, the ash content of the leaves was significantly increased. The addition of limestone increased the ash content of leaves in other treatments, but to a lesser extent than in the case of Soller mulch. The calcium content of leaves from the Toa mulch

plots without limestone was appreciably lower than that from other plots. The addition of limestone to Toa, Soller, and Catalina mulches significantly increased the calcium content of the leaves. Leaves from Soller mulch plots, either with or without limestone, had a relatively high percentage of calcium, indicating that this mulch material is rich in that element. Leaves from Soller mulch plots also contained a relatively low amount of magnesium, which was further depressed when limestone was added. The magnesium content of the leaves of plants in other mulches was also depressed when limestone was added, but to a lesser extent than with Soller.

The potassium content of leaves from all treatments was high and relatively uniform, indicating that the three types of mulches contain sufficient amounts of this element to meet growth requirements. The phosphorus content of the vanilla leaves varied from 0.58 to 0.87 percent. The lowest phosphorus content generally occurred in leaves from plots to which limestone had been applied. The phosphorus content of leaves from all plots was relatively high. The nitrogen content of the leaves varied less than any other constituent. The lowest nitrogen percentage found was 2.27, and the highest 2.40. Apparently adequate amounts of nitrogen were supplied by all mulch treatments. There was no consistent difference in the mineral composition of the leaves under one-third and one-half light.

Vanilla Breeding. H. R. Cibes and N. F. Childers

Hybrid vanilla seedlings growing on agar in test tubes were received from Dr. Lewis Knudson of Cornell University. The seedlings were from crosses made in Puerto Rico between *Vanilla fragrans* and *V. phaeantha;* seed were sent to Dr. Knudson, who germinated and grew them by a special technique he developed. *V. fragrans* is the widely grown high-quality commercial species which is highly susceptible to the vanilla root rot disease (*Fusarium batatatis* var. *vanillae* Tucker); *V. phaeantha* has a low quality bean but is relatively resistant to the root disease as well as drought, excessive sun, and low soil fertility. The seedlings were transferred from the agar to 3-inch pots containing peat moss and expanded mica, where they will remain until ready for transplanting to the field.

Vanilla Curing. C. F. Cernuda

A simple formula was derived for calculating the weight to which fresh vanilla beans should be reduced to obtain a desired moisture content after conditioning. Different factors are used for vanilla beans in different stages of maturity. These are available in table form for easy reference. Data obtained experimentally by previous investigators served as a basis for obtaining such factors.

GINGER

Agronomic Studies. H. J. Cruzado

Ginger planted in Toa silty clay loam with six different fertilizer treatments failed to show statistically significant differences in yield. Two similar fertilizer trials were made in 1945–46 and 1946–47. The growth, in general, was very poor, especially on the plots with leafmold treatments. The results indicate that there is no basis for recommending any of the treatments for growing ginger under conditions similar

to those under which these trials were made. It was noted that ginger plants that were shaded grew better, were dark green in color, and produced higher yields than plants grown in full sun.

Curing Experiments. C. F. Cernuda

Ginger harvested 6 months after planting was immersed in 10, 15, and 20 percent brines for periods of 2, 4, and 6 weeks. Samples immersed in the brine of lowest salt concentration for 4 weeks gave the best product; those pickled with 20-percent brine gave the least desirable product. Ginger hands candied without pickling were slightly dark in color, highly pungent, and fibrous. Ginger rhizomes that were pickled and then boiled under pressure gave a tender product but were dark in color, fibrous, and pungent. Boiling in an open kettle gave an attractive color to the candy. Tenderness could be controlled by the extent of boiling. The best results were obtained by boiling from 10 to 15 minutes. The softer the texture of the rhizomes before preserving them in sirup, the better the penetration of sugar to the inner tissues. The optimum degree of softening was reached when biting was easy. Excessive rupturing of the tissues resulted in rapid dehydration after candying. Conditioning the candied ginger in a cool, dry atmosphere prevented it from becoming dry and rigid, and also preserved the attractive glace sugar coating.

In another experiment in which the rhizomes were boiled several times, the water being changed each time, only a slight reduction in "biting" properties was observed. This suggests that most of the ginger resins are insoluble in water. Ginger hands, pickled, boiled in water, de-salted with running water, and boiled in sugar sirup (22° Bé.) at the beginning of each immersion period, were less sharp in biting quality but retained the characteristic ginger flavor. The end product, however, was darker in color. Boiling ginger in sirup seemed to affect the resins responsible for pungency, and thus minimized this undesirable characteristic.

Several agents, such as lye, lime, chlorox, and hydrochloric acid, were tested as blanching agents in removing the skin from ginger rhizomes. Only lye seemed to have any desirable effect. The best results were obtained with a 10-percent lye solution at 100° C. Under these conditions the rhizomes were completely peeled in 3 minutes. The peeling time-lye concentration curves were irregular, and a direct relationship between these two factors could not be established. Neutralization of the alkali with citric acid and flushing with water proved impractical. After removal from the lye solution the rhizomes bleached to a pale, whitish color and had little ginger flavor, but were still pungent. Peeling of ginger can be easily accomplished by immersion in lye, but the complete removal of the alkali is questionable.

BAMBOO

Distributions. R. Ferrer Delgado

In cooperation with the Insular Forest Service the station distributed the more important introduced bamboo species for propagation in the watershed-protection program. During the year, 1,300 clump divisions of *Bambusa tuldoides* Munro, 4,075 of *B. tulda* Roxb., 500

of *B. longispiculata* Gamble ex Brandis, and 558 of *Dendrocalamus strictus* (Roxb.) Nees, were planted in the watershed of Luquillo. In addition the station has supplied to private individuals, particularly through the Soil Conservation Service, 1,078 clump divisions of *B. tuldoides*, 1,913 of *B. tulda*, 31 of *B. longispiculata*, 60 of *D. strictus*, and 10 of *B. multiplex* (Lour.) Raeusch. These clump divisions not only serve for controlling soil erosion but also produce good, usable canes for sale or for home use. A considerable quantity of bamboo species was shipped to the cooperative experiment stations of the Office of Foreign Agricultural Relations in Latin America. In cooperation with the Puerto Rico Industrial Development Company, 17,575 linear feet of cured culms of *B. tulda* and 45 pounds of side branches were made available to local bamboo industries.

Agronomic Studies. R. Ferrer Delgado

The results of a bamboo fertilization experiment showed that more new shoots sprouted from the fertilized clumps of all the species, except *Bambusa textilis* McClure, than from unfertilized ones. Fertilized clumps of *B. textilis* had fewer new shoots, but a greater percentage of those that sprouted developed into culms. In all the fertilized clumps the diameter, height, and basal circumference of the culms were greater, but the the differences were not significant.

A planting of *Bambusa tulda* was made in 1946 at three different spacings, 15 by 15 feet, 20 by 20 feet, and 25 by 25 feet, on a Catalina clay soil in Cidra. The most recent growth measurements showed that the clumps planted at 25 by 25 feet are making better growth than those planted closer. Since this planting is only 20 months old, the results are not conclusive nor consistent at this time.

More than 50 percent of bamboo seed stored over calcium chloride for 2 years remained viable and germinated. The seed stored without a dehydrating agent, over hydrated lime, or over powdered charcoal failed to germinate.

Propagation Studies. R. H. Hageman and R. Ferrer Delgado

The use of dynamite in removing bamboo for propagation, especially on the larger clumps, required the expenditure of one-fourth the man-hours and was one-half as expensive as removal by hand digging; on the smaller clumps the use of dynamite reduced the time consumed to one-third, though the total cost was slightly greater than digging by hand. It is possible that small clumps may be excavated with fewer sticks of dynamite and electric caps than used in this trial. The dynamite blast did not damage the bamboo, as the entire mass clung tightly together and was lifted out in a solid saucer-shaped chunk. In general, not over one or two clump divisions were shattered per clump. The clump divisions that were blasted out when planted, sprouted and grew as well as did those that were dug by hand.[9]

MISCELLANEOUS

Deionized Water. A. J. Loustalot, R. H. Hageman, and C. Pagan

A system for preparing deionized water by means of ion-exchange

[9] Hageman, R. H., Ferrer Delgado, R., and Childers, N. F. the use of dynamite in lifting bamboo clumps for propagation. Trop. Agr. [Trinidad]. [In press.]

resins, "Amberlite," was constructed in the station greenhouse to facilitate experimental work involving mineral nutrition of plants. The system is of such capacity that 300 gallons of deionized water can be obtained daily. The quality of deionized water obtained by the Amberlite treatment is superior to that obtained by ordinary distillation from metal stills. Water, after passing through Amberlite, is comparable to redistilled water in cation content. The copper and zinc content is as low as that of redistilled water.

The Amberlite system not only produces high-quality deionized water, but is relatively inexpensive to operate. If the resins are protected from direct sunlight they do not decompose appreciably with time, and the only up-keep involved is the cost of hydrochloric acid and sodium carbonate used in regenerating the resins. This is less than one-half cent per gallon of water. The cost of the apparatus, including the large glass tubes and resins, was $70. Smaller units adapted for laboratory use can be constructed for considerably less.

COFFEE

AGRONOMIC STUDIES. J. Lería [10]

Yields of the Columnaris variety of *Coffea arabica* L., from Java, and the West Indian variety were compared for the fourteenth crop year in 1947. Columnaris variety yielded 2,025 pounds per acre of marketable coffee in 1947 against 1,011 pounds for the Puerto Rican variety. The average acre-yields over a 14-year period leave the Columnaris variety well in front with 1,142 pounds as compared with 647 pounds for the West Indian variety.

WEATHER

YEARLY DATA. W. Vargas

The rainfall for the last 6 months of 1947 was 31.13 inches, or 18.72 inches below the 49-year average. For the first 6 months of 1948 the rainfall was 26.87 inches, or 3.14 inches below the 50-year average. Only January, February, and June had above-average precipitation. The rainfall for the remainder of the year, especially for the months of July, November, December, March, and April, was well below the 49-year average. The total rainfall for the fiscal year 1947–48 was 58.00 inches, which was well below the 49-year average of 79.86 inches. The mean temperature record at Mayaguez, P. R., for the fiscal year 1947–48 was 77.6° F., which was only 0.3° higher than the 49-year average of 77.3° F.

PUBLICATIONS ISSUED

The following publications were issued during the year:

CHILDERS, N. F., and CIBES, H. R. Vanilla culture in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 28, 94 pp., illus. 1948.

PLANK, H. K. Biology of the bamboo powder-post beetle in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 44, 29 pp., illus. 1948.

[10] Member of the staff of the Agricultural Experiment Station of the University of Puerto Rico.

WHITE, D. G. Bamboo culture and utilization in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 29, 34 pp., illus. 1948.

The following articles were published in periodicals of the Department:

FREYRE, R. H. More guavas in Puerto Rico. Agr. in Americas 7: 113–115, illus. 1947.
HUME, E. P., and WINTERS, H. F. Tomatoes from a tree. Foreign Agr. 12 (6): 121–122, illus. 1948.
WHITE, D. G. Mulching tropical plants. Agr. in Americas 7: 143–145, illus. 1947.

The following articles were published by the station staff in periodicals outside the Department:

BARTLETT, K. A. The Federal Experiment Station in Puerto Rico. Sugar 10 (11): 3–6, illus. 1948.
CHILDERS, N. F. Una hierba ideal para cesped en los tropicos. Rev. de Agr. de Puerto Rico 38: 39–42. 1947.
CHILDERS, N. F., and TELFORD, E. A. Más experiencia con el kudzu tropical. Rev. de Agr. de Puerto Rico 38: 77–82, illus. 1947.
CIBES, H. R., CHILDERS, N. F., and LOUSTALOT, A. J. Influence of mineral deficiencies on growth and composition of vanilla vines. Plant Physiol. 22: 291–299, illus. 1947.
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JONES, M. A., and PAGÁN, C. Experiments in the drying of Derris and Lonchocarpus roots. Trop. Agr. [Trinidad] 24: 88–93. 1947.
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LOUSTALOT, A. J., WINTERS, H. F., and CHILDERS, N. F. Influence of high, medium, and low soil moisture on growth and alkaloid content of *Cinchona ledgeriana*. Plant Physiol. 22: 613–619, illus. 1947.
MANGUAL, J. C. 2,4-D increases herbicidal action of Concentrate 40 and oil emulsion. Science 107 (2768): 66. 1948.
PLANK, H. K. DDT for powder-post beetle control in bamboo. Science 106 (2753): 317. 1947.
SEQUINOT ROBLES, P. Experimentos en Puerto Rico con variedades de hortalizas a tres altitudes. Rev. de Agr. de Puerto Rico 39: 15–20, illus. 1948.
TELFORD, E. A., and CHILDERS, N. F. Tropical kudzu (a promising legume for Puerto Rico). Rev. de Agr. de Puerto Rico 38: 92. (Abstract). 1947.
TELFORD, E. A., and CHILDERS, N. F. El kudzu tropical en Puerto Rico. Hacienda 42 (10): 50–52, 54, illus. 1947.
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WHITE, D. G., and MANGUAL, J. C. A comparison of the use of herbicides used in sugarcane. Sugar 43 (4): 31–35, illus. 1948.

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